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ORIGINAL ARTICLES

EXPERIENCES WITH STEINMANN'S NAIL-EXTENSION METHOD IN FRACTURES OF THE FEMUR.[1]

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The essential part of Steinmann's[2] method consists of a nail which transfixes the soft parts and bone, and which is the sole point of attachment for suitable traction upon the lower fragment. In other words, the bone and soft parts are transfixed by a drill which is left in place with both its ends projecting.

Apparatus. The steel nail is 3½ mm. thick, 18 to 20 cm. (7 to 8 inches) long; the ends should project 2½ to 3 cm. beyond the skin (Fig. 1). The nail may be driven through the bone either by a simple handle resembling a clock key, or by a bit and brace, or by a geared hand drill (Fig. 2). An adjustable pair of tongs (Fig. 3), the limbs of which are joined by a suitable thumbscrew, forms the most convenient means of attaching extension apparatus to the nail ends.

In describing the typical procedure, let us take, for example, the treatment of a fracture of the femoral shaft at its middle third. The sterilized nail and drilling mechanism are fitted together and placed in readiness. The entire limb is brought close to the margin of the table or bed, so as to prevent interference with the drilling that is to follow. One assistant grasps the patient's ankle and, maintaining traction, elevates the leg, while the operator who is "sterile" applies full-strength tincture of iodine to the skin and does the necessary draping. The leg is then lowered, so that ankle and knee are close to the edge of the table. Another assistant having sterilized himself, assumes management of the broken limb. The anesthesia (gas) is now started. The assistant steadies the limb (outer margin of the foot must stay vertical), at the same time pulling the skin of the thigh upward. The point of the nail is inserted horizontally and at right angles to the shaft *a finger's-breadth above the upper margin of the external condyle.* As soon as the bone is touched, drilling is begun (Fig. 4). The operator controls the drill with both hands and leans his body, either chest or groin, against the breast-piece of the drill. The resistance which at first is encountered, lessens after a while, for penetration is easier after the corticalis is passed, as the cancellous tissue offers less resistance. Again, progress is slower as the corticalis of the opposite side is encountered. Finally, this also is passed and

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[1] Read before the Surgical Section of the New York Academy of Medicine, January 3, 1913.

[2] Nagel extension der Knoche brüche, Neue Deutsche Chirurgie, 1912, Band i; British Med. Jour., November 30, 1912, p. 1235.

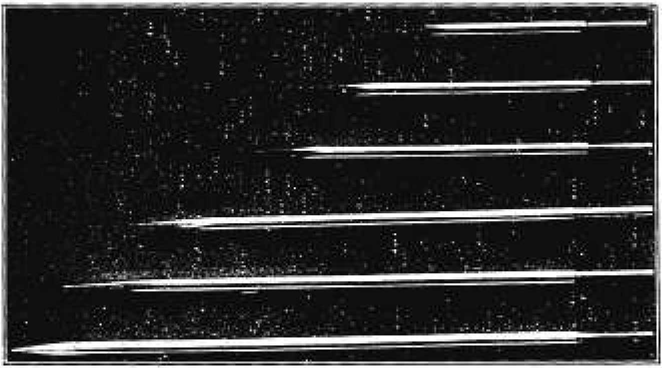

FIG. 1.—Solid nails of varying lengths. The points are sharpened on four sides; the heads are round in order to fit the chuck of the hand drill.

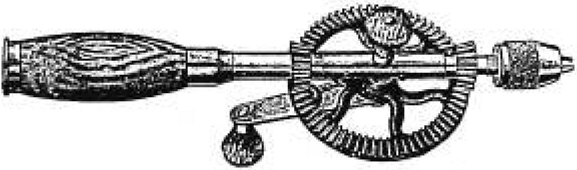

FIG. 2.—Geared hand drill.

the nail point may be felt emerging from the bone. The skin overlying the nail point is pulled upward by the assistant and the

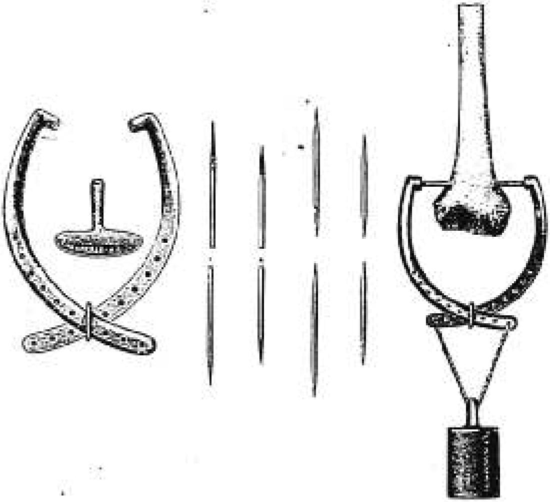

FIG. 3.—Tongs with nails, solid and two piece, and handle.

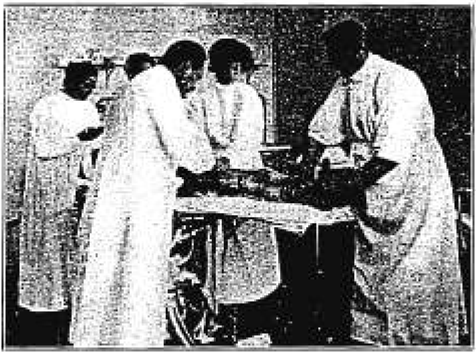

FIG. 4.—Transfixing the lower end of the femur. (Steinmann.)

point finally emerges. Drilling is stopped when the two nail ends project equally on either side of the limb. The narcosis is then stopped. The skin which the penetrating nail point has carried away from the leg is now pushed back on the nail to the level of the adjacent skin. Tincture of iodine, then aristol, and lastly collodion are applied to the skin where the nail emerges. Small flat pieces of folded gauze are transfixed by the nail points and run down the nail shaft to the skin.[3] A figure-of-eight bandage holds them in place; it is well for some turns of the bandage to be transfixed by the nail points.

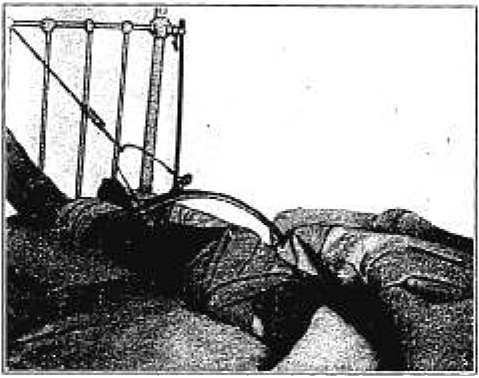

FIG. 5.—Case VI. Nail in supracondylar position. Note wire fastened to ends of crossed limbs.

The extension apparatus is now attached to the nail. The two limbs of the tongs are applied so that the thumbscrew holding them comes uppermost—each limb is applied separately—the screw being inserted in that hole of either limb which most readily falls in alignment. The ends of a short piece of wire are fastened through the outermost holes of the crossed limbs of the tongs (Fig. 5). At the centre of this wire is attached the main traction wire or rope leading over a pulley at the foot of the bed down to the suspended weights. The thigh is placed in semiflexion. The leg is horizontal or the foot may be lower than the knee. The heel should not touch the bed. Hard pillows, sandbags, or suitable splints may be employed to maintain this position. The pulley at the foot of the bed must be placed so that the wire leading from the tongs is in line with the axis of the semiflexed thigh (Fig. 6).

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[3] Another nail may be used to make holes in the gauze, so that it readily slips over the rounded head of the nail which is in place.

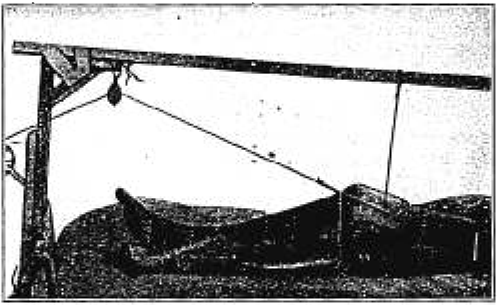

FIG. 6.—Case V. Note traction wire in line with axis of thigh, also suspension of outer end of nail to prevent eversion (rotary displacement).

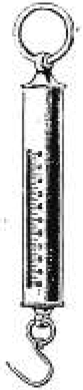

FIG. 7.—Scales.

Naturally the amount of weight to be used depends upon the individual case. In a recent fracture of an adult femur, with 5 cm. shortening, 18 to 20 pounds are usually adequate. It is very convenient to use a small spring scales registering up to 40 pounds, to ascertain how much weight is being applied (Fig. 7).

Countertraction may be obtained by (*a*) raising the foot of the bed; (*b*) a well-padded perineal loop attached to the head of the bed, and (*c*) a foot-rest for the sound limb.

Shortening is usually overcome within a week. The broken limb should be allowed to stretch 1 cm. longer than its fellow. This renders proper approximation of the fragments easier. In transverse fractures, after proper reduction, overcorrection is no longer necessary, while in oblique fractures it is well to maintain ½ or 1 cm. overcorrection until union takes place.[4] After the shortening has been overcome, less weight is required to maintain the fragments in proper position. Undue lengthening is readily corrected by simply lessening the weight—the limb promptly shortens. Massage and passive motion may be begun five days after nail-extension has been instituted. A good callus is usually developed by the end of three weeks. Steinmann states that, if possible, nail-extension should not be maintained longer than three weeks, and never longer than five weeks. Thirty-four days is the longest time I have personally seen the nail-extension maintained.

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[4] According to the painstaking investigations of Wettstein (Beitr. z. klin. Chir., 1908, Band lx, Heft 3, p. 684, and Korrespondenzbl. f. Schweitzer Aërzte, 1909, No. 3, p. 73) fractured limbs shortened ½ to 1 cm. within the year after union had occurred. To counteract this we institute overcorrection in oblique fractures.

At the end of three or four weeks there is usually sufficient callus to justify removal of the nail. If the nail is solid the end which is to be drawn through is exposed, it and the adjacent skin are carefully cleansed with tincture of iodine, which is applied most thoroughly, after this the nail is withdrawn. The rounded head is firmly grasped by a heavy pair of wire pliers. The nail is first *rotated* to loosen it and is then extracted with a rotary motion. The knee should be steadied by an assistant. Under gas the actual extraction takes less than one minute. If the nail is in two pieces, the two halves are unscrewed and pulled out, each on its own side. Some tincture of iodine is injected into the nail holes and a wet dressing is applied until the skin is healed, usually within five or six days.

Most of my cases ran a slightly elevated temperature, between 99° and 100°, while the nail was in place; this dropped again upon removal of the nail. There were no signs of infection.

The subsequent treatment is that appropriate for any limb with a fresh callus—namely, avoidance of too much strain on the callus, at the same time employment of suitable passive and active motion.

I. DETAILS OF TREATMENT. A. *Location of the Nail.* According to Steinmann (1) it should avoid the hematoma at the site of fracture; (2) it should avoid the marrow cavity;[5] (3) it should avoid the joint capsule; and (4) it should avoid the epiphyseal line. Hence the nail is inserted one finger's breadth above the upper margin of the femoral condyle just behind the middle line of the bone—in other words, through the posterior half of the supracondylar region just anterior to the adductor tubercle or its corresponding site externally.

In fractures of the lower third of the femur the nail is inserted through the upper end of the tibia 2½ fingers' breadth below the upper margin of the tibia on a level with the lower margin of the head of the fibula (Fig. 8).

B. *Methods of Inserting the Nail.* (1) Hammering has been found to cause too much pain at the site of fracture—the risk of splintering the bone is not great.[6] (2) Boring by hand is safer than by electricity. (3) Incision of the soft parts is unnecessary and increases the likelihood of infection. Other modifications of the method, such as boring a hole and then inserting the nail, etc., can be placed in the same category. (4) It is necessary to pull the skin proximally, especially in supracondylar insertion of the nail, because if this is not done, as the limb is stretched, decubitus of the skin will occur to the distal side of the nail.

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[5] At the point where the nail passes through the bone, there is enough cancellous tissue to prevent direct communication with the main marrow cavity.

[6] In a recent case of Dr. William H. Bishop's it was impossible to insert the nail by hand drilling because of the extreme hardness of the femur. The patient was a woman, aged fifty years, with a fracture of the upper third of the bone. A hammer was not available at the time, so the attempt to insert the nail had to be given up. At the subsequent plating the bone was found to be just as hard at the site of fracture, as it was near the condyles. The corticalis was very thick and there was cancellous tissue in the marrow cavity.

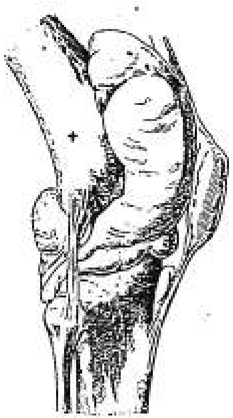

FIG. 8.—Positions for insertion of nails through femur and tibia.

C. *Type of Nail.* The two-piece nail apparently cannot be made of sufficient strength to afford a proper factor of safety against breakage at its joint. The nail has broken six out of the sixteen times I have used it. The weights used were never more than 20 pounds, usually about 15 pounds. Fortunately, when the tongs were used the broken nails were held in sufficiently good position to still maintain traction (Fig. 37). Breaking has occurred during insertion, during transport of the patient in bed to the x-ray room, and with the patient lying quietly in bed as late as the eighteenth day. I therefore prefer solid nails. Both head and point of the original nails are squared. They do not accurately fit the ordinary hand drill with a three-point contact chuck, hence I use nails with round heads which fit the usual types of drill (Fig. 2).

D. *Dressing.* Dressing should be dry and rather voluminous. The details have already been given.

E. *Attachment of Traction.* The tongs are most convenient for this purpose, but they are not essential. Braided picture wire, copper wire, or bandages (Figs. 9 and 14), may be used. In this case the ends of the nail are protected by corks. Spreaders may be necessary to prevent undue pressure of the wire against the skin in some instances, while in others an S-hook or wire loop may be required to prevent the end of the traction wire from slipping off a nail end. Where tongs are used the traction should be made upon the ends of the crossed limbs, not at the point where they cross (Fig. 6).

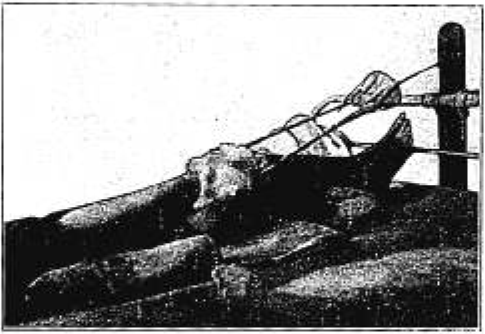

FIG. 9.—Case II. Pertrochanteric fracture. Tongs were not available, so bandages were fastened to the nail ends. Note small sandbag parallel to limb which supports the outer end of nail, thus preventing eversion.

F. *Anesthesia.* There may be a short general anesthesia, either laughing-gas or "aether rausch," or, there may be a local anesthesia (0.5 per cent. cocaine) in the cases where the former is contraindicated. In intelligent adults it is possible to do without an anesthetic, for the pain of the boring is by no means unbearable (see Case VII). Indeed, most of the pain felt is at the site of fracture.

G. *Amount of Weight.* In recent fractures this varies between 10 and 30 pounds; in old fractures between 20 and 60 pounds. Steinmann speaks of one case where an old fracture with malunion was refractured, nail-extension was applied, and a lengthening of 11 cm. was obtained within eight days. As said before, most of the stretching is done in the first week, after which much less weight suffices to maintain proper position.

H. *Control of Fragments.* The direction of the pull can be varied to adapt the lower to the upper fragment. Strong traction often causes the upper fragment to follow the lower to a great extent—that is, lateral dislocation is corrected largely by extension alone (see Case VI).

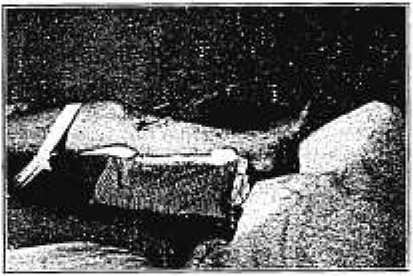

FIG. 10.—Nail-extension applied to head of tibia. (Steinmann.)

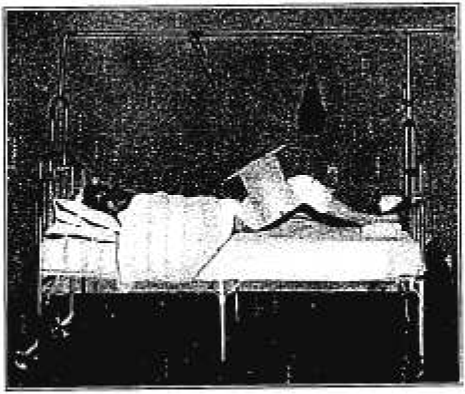

FIG. 11.—Nail-extension, with anterior pull at right angles to limb. (Waegner.)

Posterior dislocation of the lower fragment in supracondylar fractures is known to be especially difficult of correction. Flexion of the leg upon the thigh and dorsal flexion of the foot upon the leg lessens the pull of the gastrocnemii upon the lower femoral fragment which is displaced backward. Traction at right angles to the leg also aids in correction of this condition (Figs. 10 and 11).

Rotary displacement (eversion) is best corrected by suspension of one nail end. This is most conveniently accomplished by two uprights and a horizontal bar running the length of the bed, with a wire attached to the lateral (outer) end of the nail and to the horizontal bar (Fig. 7). In fact, the entire limb may be most conveniently suspended by this simple means.

It is unnecessary to review all the modifications and varieties of lateral traction and suspension which have been employed in other extension methods, notably in that of Bardenheuer. It goes without saying that they have been employed in the Steinmann method since 1907 with even better chances of success.

If possible, *x*-ray plates should be made before extension is applied; afterward controls can be made at proper intervals to make sure of proper position. As a matter of course the exposures should be made both from in front and from the side. Portable *x*-ray outfits are becoming quite common. With one of these exposures can be made without disturbing the limb. In hospitals without portable *x*-ray apparatus, a bed-truck may be used to transport the patient in bed into the *x*-ray room. A physician should accompany the patient upon this journey. The personal supervision of transport by one who understnds the *rationale* of the apparatus will prevent unnecessary pain to the patient and undue strain upon the apparatus. As said elsewhere, jarring by rather light weights (15 pounds) during transport has been sufficient to break the two-piece nail at the joint.

Even when the *x*-rays are not available, very fair results can be obtained by careful daily control with tape measure and fingers. While measurement is being made, the sound limb must be flexed to the same degree as the fractured one. It is well to measure from a number of points for the sake of control, for example, from the anterior spine to the nail, as well as to the internal malleolus.

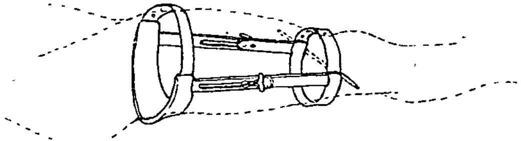

FIG. 12.—Splint for maintaining extension during transport to the *x*-ray room. (Steinmann.)

Steinmann has devised a sort of hip splint which can be adjusted so that its upper margin rests against the pelvis, and its lower margin impinges upon the projecting nail ends; it thus prevents shortening when traction is taken off. This splint was designed to facilitate the transport of patients to some place where an *x*-ray exposure can be made (Fig. 12). From what I have seen, the less a patient is moved after extension is once applied, the better.

II. OBJECTIONS WHICH HAVE BEEN MADE REGARDING STEINMANN'S METHOD. A. *Pain.* (1) Upon introduction of the nail an anesthetic is usually employed, yet under unusual circumstances it may be dispensed with (see Case VII). (2) During extension no pain is felt at the site of the nail. If traction is irksome the weights may be lessened for a few hours and then added again. (3) At removal of the nail there may be slight pain. By this time the nail is loose in the bone except when lodged in the head of the tibia, from which its extraction may require considerable force. It is well not to allow children or excitable adults to know that a nail is being employed. As long as they are ignorant of its presence they do not complain. A voluminous dressing applied to the leg satisfactorily conceals things.

B. *Infection* occurs either at the time of insertion or after two or three weeks. It is easy to insert the nail aseptically, but it is difficult to keep the region aseptic in the later stages. The granulations which have formed by the end of three weeks afford a fairly good protection to the bone at large. Small local infections have been known to occur, especially in long-continued cases of extension. These have all remained localized. Small circular sequestræ have come away. A small exostosis occasionally develops at the site of the nail. So far there has been no mortality from nail-extension—carried out according to the rules laid down by Steinmann. Fatal cases are known where the wound made by the nail has established communication with the fracture hematoma, thus converting a simple into a compound fracture.

C. *Injury by the nail to important nervous, vascular or articular structures.* There has been none at the time of insertion. Steinmann even reports a case where the nail had been run through the ankle-joint without causing any functional trouble.

The epiphysis has not been harmed, as shown by four years' observations upon children on whom this method had been employed. There was no lessened growth of the injured side.

D. *Injury by too great traction* has been ascribed to nail extension. There has been no instance of harm to the soft parts. An extreme example of what can be accomplished is shown by the case of Steinmann's, where 11 cm. lenghtening was obtained within seven days in a refractured malunion of five or six months' standing. There was no loss of function.

E. *Lax Knee-joint.* Strong diversity of opinion exists regarding injury to the knee-joint by traction (such as Buck's extension) applied to the limb below the knee. Naturally this controversy will promptly transfer itself to application of the Steinmann method in fractures of the lower third of the thigh where the nail is inserted through the head of the tibia; hence, a brief outline of the situation seems proper here.

Certain observers emphatically state that they have observed the most harmful effect upon the knee-joint from extension applied to the leg below the knee. Other equally competent authorities maintain that they have never seen any injury to the knee-joint from application of Buck's extension to the leg as well as the thigh, and furthermore insist that no adequate extension can be obtained by merely pulling on the skin of the thigh.

It is to be noted that Steinmann's method differs from Buck's extension in that the knee-joint is flexed, whereas in Buck's extension the knee-joint is fully extended. Perhaps there is less strain upon the ligaments when traction is applied to the partially flexed joint than when there is full extension. My own experience in this matter is not sufficiently extensive to be of much value. Steinmann states that he has never seen any distraction of the knee-joint from traction upon the tibia. He also states that effusions into the joint disappear with great rapidity after extension is made; this likewise has been my own experience. The transient inability fully to extend the knee rapidly disappears under appropriate massage and passive motion.

F. *Delayed Union.* None has been observed so far. On the contrary, Steinmann says that firm union is usually obtained in seven or eight weeks, in some cases even as early as five weeks. The fact that both passive motion and massage can be employed while extension is going on certainly has much to do with prompt callus formation and union. No pseudarthroses have occurred.

III. ADVANTAGES. A. *Traction.* Less weight is needed for any given case than by other methods. More weight can be used than by any other method, and this without the risk of decubitus. The traction is continuous, not spasmodic, as in Codivilla's method or in Lane plating. In cases of long-standing malunion the soft parts may be so contracted that, after freeing their ends, the bones cannot be placed end-to-end without undue tension upon the soft parts which may cause cessation of circulation in the distal part of the extremity or even rupture of important structures. It is in such cases that the continuous traction safely accomplishes its purpose in from three to five days.

B. *Painlessness.* Once the nail is in position there is no pain due to its presence. In fact, after a few days the patients are apt to become careless because of their freedom from pain.

C. *Control of the fragments,* especially of the lower one, is more certain by this method than by any other except the open operation.

D. *The small site of attachment* makes the method available in the compound fractures where other traction methods are either difficult or impossible of application.

Simplicity and possibility of improvisation are qualities of the method which cannot be too strongly praised. Steel drills and the apparatus for driving them, or long nails, together with some wire or stout cord, are obtainable almost anywhere, and they can be made to serve one's purpose.

The value of the method in military or naval serivce or in inaccessible regions, is readily apparent. The Prussian army uses it. It is time-saving, effective, and easily learned.

Comparison of Results. With Buck's extension we have more or less shortening and stiffness of the knee, which lasts for a long time afterward. With the Steinmann method there is no shortening, and the transient inability fully to extend the knee-joint quickly disappears. In some cases it is never present.

With Lane plating we have the risk of grave infection if the operation be done by any except the skilled, and in any case, somewhat delayed union. In certain exceptional cases even with no infection, union may be delayed for months, and long immobilization of the knee-joint in such cases has resulted in what amounts to an ankylosis. With the Steinmann method there is much less risk of infection (there have been no fatal cases so far); there is no delayed union (in the average case), and the joints have little, if any, impaired function.

The method of Ransohoff,[6] whereby the point of a pair of ice-tongs are lightly driven into the bone, is a recent modification of the same principles governing nail extension. The site of attachment with tongs is larger than with the nail.

IV. INDICATIONS FOR USING NAIL EXTENSION. A. *Recent Fractures.* Fractures of the femoral neck constitute debatable ground. Impacted fractures of the neck against the head had better be left alone. Intracapsular fractures in the young show brilliant results when spiked in their proper position at operation. Where operation is contraindicated, Whitmann's abduction is the most rational method for properly approximating the fragments. Pertrochanteric fractures, on the other hand, give excellent results with nail extension (Cases II and V).

In fractures of the shaft, in very obese individuals where adhesive plaster is not effective, nail-extension is indicated (Case VII).

In supracondylar fractures it affords better control of the lower fragment than any other traction method.

In short, nail extension is indicated wherever the usual traction methods fail. A case of von Eiselsberg's, quoted by Steinmann, illustrates this. In a fresh fracture of the lower third of the femur it was found that there was such pressure upon the popliteal artery that the pulse was obliterated. Traction by the usual adhesive plaster did no good. Nail extension was then resorted to and the pulse returned.

B. *Old Fractures.* This is a field which has been practically untouched by traction methods. The fact that nail-extension can be employed with success at a considerable time after the fracture has occurred, makes it of value when a fracture is complicated by extensive abrasions of the skin or by acute disease, such as delirium tremens or pneumonia. Here one can wait until recovery has taken place before applying extension. The method has been successfully used in fractures of forty days' standing in which usual traction methods have been of no avail.

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[6] Lancet-Clinic, August 17, 1912.

In malunion with much overriding, operation followed by the Steinmann method is the only way in which an ideal result can safely be obtained. The malunion is broken up, and afterward nail-extension is applied. Naturally, larger weights (up to 60 pounds) must be employed. This procedure has been used as late as three to six months' after malunion had taken place.

In pseudarthroses, rubbing of the bone ends together, followed by application of extension, has been suggested. When this is not sufficient the bone ends may be cut down upon and freshened, the wound then closed and nail-extension applied.

As a preliminary to Lane plating in cases where that method is indicated (interposition of soft parts, etc.) nail-extension is excellent, because the absence of shortening lightens the operator's task fully 75 per cent.

To conclude, in certain cases nail-extension is the only method to be used, in others it is an aid to previously existing methods.

I take the opportunity of expressing my gratitude to Drs. Howard Collins, William H. Bishop, A. G. Gerster, John A. Wyeth, Seth Milliken, and Ernest Fahnestock for their kindness in allowing me to employ this method in their services and for the privilege of publishing their cases, the abstracts of which follow (Cases I, II, III, V, VI, VII, IX, and X were presented at the time this paper was read).

SYNOPSIS OF CASES.

CASE I. James L., aged four and one-half years (Dr. Howard Collins' service, City Hospital, Blackwell's Island).

June 26, 1912. A board fell from a building and struck the patient, causing an oblique fracture of the middle third of the left femur. Admitted to City Hospital on June 27.

July 2. Sixth day after fracture. Steinmann two-piece nail; supracondylar insertion. Laughing-gas anesthesia; 6 pounds traction; 1 cm. shortening.

July 9. ½ cm. overcorrection; 4 pounds traction.

July 22. ¾ cm. overcorrection.

July 23. Twenty-first day. Nail removed. (X-ray, Fig. 13.)

July 25. Limbs equal; nail holes clean.

August 3. Child can raise entire limb to vertical position; flex and extend knee. Nail holes, two small clean, granulating spots.

October 5. Function perfect; runs and walks without a limp.

Epicrisis. This was a restless, active child who had no pain after the first three days, and who had to be restrained by loops of bandage at the ankle, knee, hip, and armpit in order to maintain proper alignment of fragments (Fig. 14).

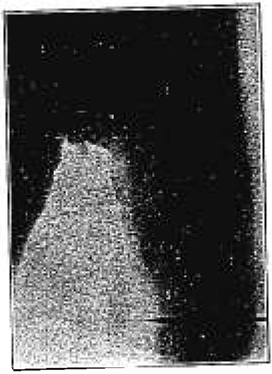


FIG. 13.—Case I. Plate taken twenty-one days after fracture; no shortening.

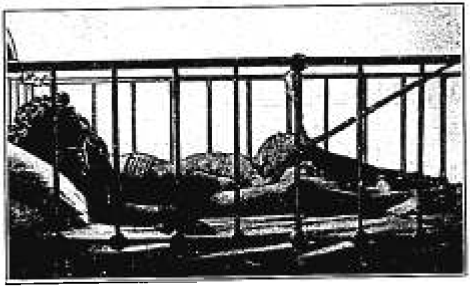


FIG. 14.—Case I. Illustrating restraint necessary with active children to maintain proper alignment of fragment.

CASE II. James R., aged sixty-five years (Dr. Howard Collins' service, City Hospital, Blackwell's Island).

June 14, 1912. Admitted to Bellevue Hospital with a fracture of the neck of the femur.

June 21. Transferred to the City Hospital, with a shortening of 1½ inches and marked eversion.

June 22. Buck's extension with 10 pounds traction applied.

July 1. Sixteenth day after fracture 3 cm. shortening. Steinmann two-piece nail; supracondylar insertion under laughing gas; 21 pounds traction (Fig. 11).

July 12. ½ cm. shortening.

July 18. Eighteenth day after insertion. Nail broke at joint; inner half loose and removed; wet dressing applied to nail hole. Outer half was solid (Fig. 13), and sandbag, which had been placed underneath its end to prevent eversion, and to maintain the limb in proper position, was left undisturbed.

July 19. 1 cm. shortening; x-ray plate (Fig. 15).

Fig. 15.—Case II. Pertrochanteric fracture nineteen days after extension applied.

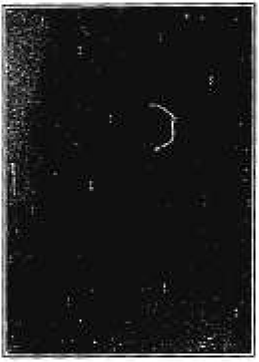


Fig. 16.—Case II. The same five months later.

July 23. Outer half of nail removed.

July 27. Nail holes healed; good union; massive callus.

July 29. 2 cm. shortening; patient comfortable.

August 14. Patient is encouraged to sit up and to try to walk on crutches.

August 28. Shortening nearly 3 cm.; good flexion and extension; some limitation to inward rotation. Edema of right leg and ankle, which has existed since patient was out of bed on crutches, gradually subsiding under massage.

December 1. Patient has been on crutches for the past three months. Has now been encouraged to walk.

December 23. Bad dermatitis of right leg and ankle from undue use of chloroform liniment.

December 30. X-rays (Fig. 16) show neck joined to the shaft at more of a right angle than previous picture; firm union.

Epicrisis. The nail broke on the eighteenth day. Traction was being made by bandages fastened to the projecting ends of the nail. No tongs were available at that time, and it was not feasible to apply other methods of traction. Had extension been maintained for a week longer, it is probable that no shortening would have ensued after removal of traction. Where the two-piece nail has broken with the tongs grasping its ends it has been found possible to still maintain traction, since the tongs hold the fragments of the nail at approximately right angles (see Case XII).

CASE III.—Mary H., aged seven years (Dr. Howard Collins' service, City Hospital, Blackwell's Island).

August 24, 1912. Fell three stories to the ground from a fire-escape, striking a shutter, and other fire-escapes on her way down, sustaining a fracture of the lower third of the right femur. A projecting fragment could be felt in the popliteal space. There was no obstruction to the circulation; 3 cm. shortening.

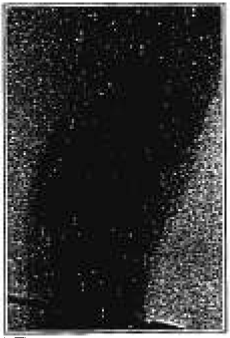


FIG. 17.—Case III. Supracondylar fracture before reduction.

August 26. Second day after fracture. Under laughing-gas anesthesia. A two-piece nail driven through the head of the tibia; 8 pounds traction.

August 28. ½ cm. shortening.

September 3. X-rays show lower fragment displaced outward (Fig. 17).

September 9. Reduction of fragment under laughing-gas, by Dr. A. L. Sherman.

September 19. Twenty-fourth day, nail removed.

September 26. Excellent union; patient can raise heel from bed, flex the leg completely, and extend it to within a few degrees of full extension.

October 10. *X*-rays (Figs. 18 and 19) show excellent position.

October 18. Out of bed for the past few days; can now fully extend leg; limps less and less as time goes on.

October 19. Discharged from hospital.

November 14. Some effusion of knee-joint, which the mother says has been present since leaving the hospital. Limp barely perceptible.

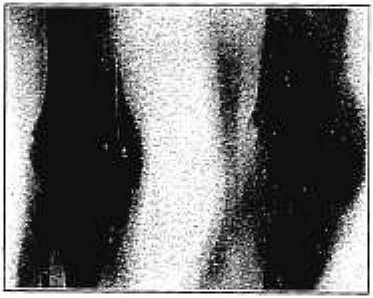


FIG. 18.—Case III. Both knees after reduction.

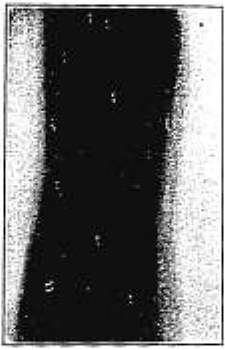


FIG. 19.—Case III. Final result.

December 24. Effusion of knee gone; walks and runs with perfect freedom.

Epicrisis. There was union within one month. Slight limitation to full extension, which was present for a time after removal of the nail, gradually disappeared. The effusion of the knee-joint was present for five or six weeks after discharge from the hospital, and subsided without treatment.

CASE IV.—John H., aged eighteen years (Dr. Howard Collins' service, City Hospital, Blackwell's Island).

September 30, 1912. Was hit by an automobile mud-guard while roller-skating in the street. He was knocked senseless, and sustained a fracture of the middle third of the left thigh.

October 1. A large effusion of the knee-joint. Shortening about 4 cm.

October 3. Fourth day after fracture, Steinmann's two-piece nail inserted through the head of the tibia; 10 pounds traction.

October 5. Shortening 2.5 cm.; 18 pounds traction. Effusion of the knee-joint gone.

October 10. 1 cm. overcorrection.

October 23. Twenty-first day. Nail removed. Some force necessary because of its firm fixation in the tibia.

October 25. Plaster spica applied, reaching to the hip. At this time there was slight lateral mobility, considerable callus, and it seemed as though the upper fragment had moved anteriorly. There was slight lateral mobility of the knee-joint; no limitation to passive motion of the knee-joint.

Fig. 20

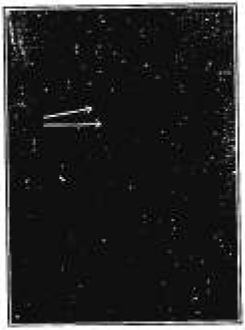


Fig. 21

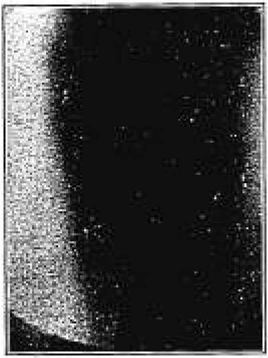


Fig. 20.—Case IV. Transverse fracture seen from in front.

Fig. 21.—Case IV. The same seen from the side. The plate taken at the same time as Fig. 20. was lost, but it showed the same position as this plate (Fig. 21), which, together with Fig. 22 was taken two months later.

October 31. X-rays (anteroposterior view) show good position (Fig. 20). Lateral view (Fig. 21) shows overriding of transverse fragments. This was the first time this case had been x-rayed.

November 6. Cast removed. Up in rolling-chair.

November 15. Patient slipped getting into chair and fell on the floor.

November 17. There was marked bowing and 2½ to 3 cm. shortening. Supracondylar insertion of nail was suggested as the best available traction. This was refused by patient. Because of this, Buck's extension (15 pounds) and lateral traction (15 pounds) at the greatest prominence of the bowing were applied.

November 26. Bowing of thigh has gone; lateral traction discontinued.

December 1. Buck's extension discontinued; 1 cm. shortening present at this time.

December 22. Patient has lain quietly in bed the past three weeks, the leg being in the same position that it was while Buck's extension was being maintained. There was 2 cm. shortening. Flexion beyond 60 degrees limited. Full extension. Some effusion of knee-joint ever since discontinuance of Buck's extension.

December 24. X-rays show good callus and slight overriding of the fragments (Figs. 21 and 22). There is no angulation of the thigh.

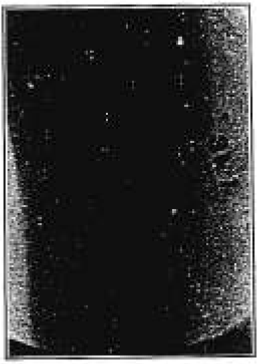


FIG. 22.—Case IV. Front view two months later than Fig. 20.

December 30. Home on crutches, with a perfectly solid union.

Epicrisis. There were no facilities for controlling treatment by the *x*-rays. Because of the extensive effusion of the knee-joint and because of the contusions of the thigh, it was deemed wiser to apply traction to the head of the tibia rather than to run the risk of possibly infecting a hematoma of the thigh. A better result might have been obtained had a solid nail been used in the supracondylar region and had it been possible to follow effects of traction with the *x*-rays. It seemed unwise to use more than 20 pounds weight with traction on the head of the tibia.

CASE V.—John M., aged thirty years (Dr. William H. Bishops' service, Flower Hospital, New York.)

October 10, 1912. Fractured neck of femur while trying to stop a runaway. His foot slipped and the wheel struck him, knocking him down. An *x*-ray plate taken at the time showed an extracapsular fracture passing through and below the greater trochanter.

Unfortunately this plate was lost. There was a shortening of 1¼ inches (3.5 cm.).

October 14. Fourth day after fracture, under gas and oxygen; two-piece nail; supracondylar insertion; 15 pounds traction; external rotation prevented by suspending the outer end of the nail to a horizontal bar above the patient which ran the length of the bed (Fig. 7).

November 3. 1 cm. shortening.

November 12. Twenty-nine days after insertion, nail removed; no shortening; can raise knee slightly.

November 14. Plaster spica applied.

December 10. Cast removed (four weeks). Has good function.

December 11. *X*-rays show excellent position (Fig. 23).

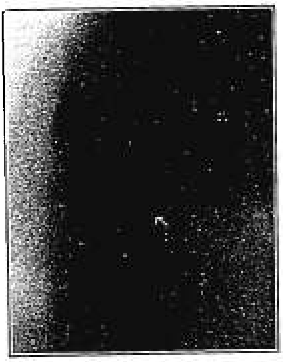


FIG. 23.—Case V. Oblique fracture beginning just below lesser trochanter and going upward through greater trochanter two months after fracture.

December 29. Walks fairly well with one crutch.

Epicrisis. Extension twenty-nine days; cast twenty-four days Uneventful course. Good result.

CASE VI.—Helen B., aged eleven years (Dr. A. G. Gerster's service, Mt. Sinai Hospital).

October 8, 1912. Was run over by an automobile. Sustained an oblique fracture of the left femur at its middle third.

October 12. Vaginal smear contained gonococci.

October 17. Ninth day after fracture, under gas and ether anesthesia; supracondylar insertion of a two-piece nail; 12 pounds; 2½ inches shortening (5½ cm.).

October 20. 1¼ inches (3 cm.) shortening.

October 24. Equal.

October 27. 1 cm. overcorrection. Traction lessened to 9 pounds. Slight adduction corrected by lateral pull 3 pounds.

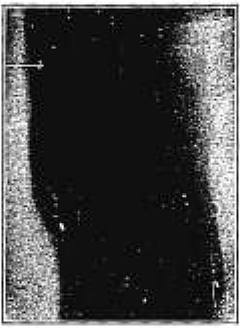


Fig. 24.—Case VI. Oblique fracture of the shaft a few days after fracture.

Fig. 25

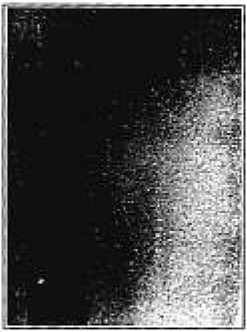
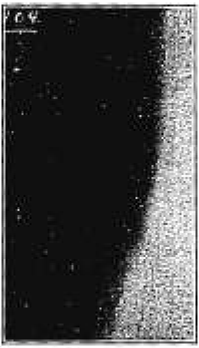


Fig. 26



Figs. 25 and 26.—Case VI. After one week of extension.

October 31. Equal.

November 8. Twenty-second day after insertion, nail removed. Good fibrous union. Slight false point of motion.

November 9. Pain in the right loin. Temperature, 100°.

November 10. Vomited a number of times; pain in right loin increased; temperature, 104.2°; urine contained many red blood and pus cells.

November 11 and 12. Temperature, 103° to 104°. Gradually subsided by lysis. Nail holes healed.

November 14. Cast (spica) applied to hip and thigh only, allowing movement of knee.

November 15. Temperature normal.

November 21. Urine contains very little pus; no albumin.

November 23. Cast removed; no shortening. Some bowing of the leg anteriorly. Has been walking on crutches for the past five days.

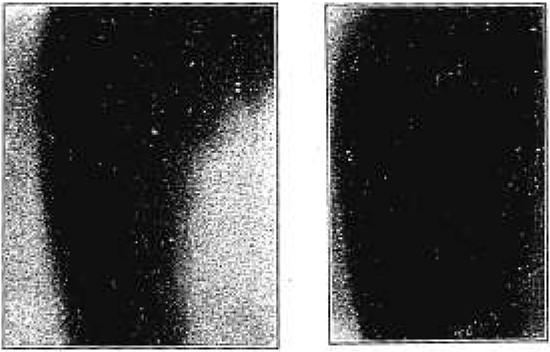


Fig. 27 Fig. 28

Figs. 27 and 28.—Case VI. Final result eleven weeks after fracture.

November 25. Discharged.

December 23. Fell and bumped knee.

December 27. Returned to the hospital for *x*-rays, which show good position (Figs. 27 and 28), Moderate effusion of the knee, which was treated with cold compresses.

Epicrisis. Nail applied on the ninth day remained in place twenty-two days. Convalescence complictaed by a smart pyelitis, probably due to the vaginal infection. Slight anterior bowing, probably due to lack of support below knee while patient was wearing plaster cast. No infection of nail holes. This was the only case of the entire series in which it was possible to follow the effect of traction with the *x*-rays.

Case VII.—Michael N., aged fifty-four years (Dr. S. M. Milliken's service, Lincoln Hospital, New York).

An extremely stout man who had varicosities of both legs for a number of years past. Non-alcoholic. He had been so asthmatic that he had been unable to work for the past six years. Five months before fracturing his thigh he contracted erysipelas of the right leg, and had stayed at home until the day of fracture, September 22, 1912, when he went out. He tripped stepping off a curb on his way to church and sustained a fracture of the upper third of the right thigh. Was taken to the Lincoln Hospital, where it was found, that besides the fracture, he had a mitral insufficiency and was extremely emphysematous. There was one inch shortening and marked eversion. A plaster spica was applied. The cast compelled him to lie flat; he nearly suffocated from his asthma that night, so that the cast had to be cut away from the abdomen in order to permit his sitting up.

Fig. 29

Fig. 30

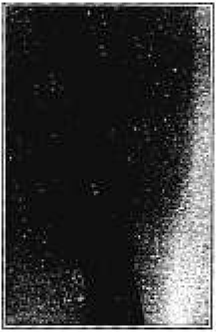
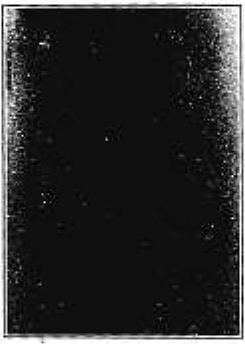


Fig. 31



Figs. 29 and 30.—Case VII. Tracing of fracture of shaft in an obese man, 250 pounds, about 5 feet 4 inches high, two days after fracture.

Fig. 31.—Twenty-five days later; good callus.

September 23. (X-rays, Figs. 29 and 30).

September 24. Cast removed.

September 26. Fourth day after fracture, shortening approximately 1½ inches. Steinmann solid nail 21 cm. long; supracondylar insertion. The thigh was so thick that the nail ends barely projected. No anesthesia; pain not extreme.

September 27. Tongs applied; 15 pounds traction.

October 2. Traction increased to 30 pounds; one inch shortening.

October 16. Nineteenth day, nail removed. Local decubitus from tongs where they grasped the end of the nail. Three-fourths inch shortening; no anterior motion; slight lateral motion.

October 17. *X*-rays (Fig. 31) show slight overlapping and large callus.

October 25. Dressing removed; wounds healed.

November 1. Lifted entire leg from bed; active motion.

November 12. Stood up for a moment (the first time) while being weighed; weight, 250 pounds. Out of bed in chair.

December 1. Out on crutches; no limitation of motion.

December 8. Discharged; on crutches.

Epicrisis. An obese asthmatic individual, wholly unsuited for Lane plating or the usual Buck's extension, in whom the nail-extension gave most satisfactory results.

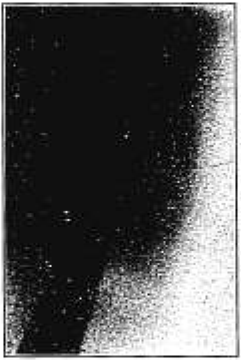


FIG. 32.—Case VIII. Taken shortly after fracture.

CASE VIII.—Arthur A., aged twenty-seven years (Dr. Ernest Fahnestock's service, J. Hood Wright Hospital, New York).

November 8, 1912. A counter-weight of an elevator struck his left thigh, causing a fracture at the middle third and rupture of the internal lateral ligament. (*X*-ray, Fig. 32.)

November 22. Fourteenth day after fracture. Had been in a posterior splint for the past sixteen days. Slight fever ever since admission; 9 cm. shortening. Two-piece nail; supracondylar insertion; laughing-gas anesthesia; 16 pounds traction.

November 23. Temperature, 102°. No local discomfort. General condition good.

November 24. Temperature normal. Traction, 21 pounds.

November 25. 2 cm. shortening. Traction increased to 23½ pounds.

December 1. 1 cm. shortening.

December 4. No shortening. Edema of leg, which was present up to now, is nearly gone.

December 24. Upon releasing weights there is 1 cm. shortening; plenty of callus; still some motion.

December 26. Nail removed (thirty-fourth day); 1 cm. shortening afterward.

December 29. 2½ cm. shortening; nail holes clean; union improving; 30 degrees motion in flexion of knee (*X*-ray, Fig. 33).

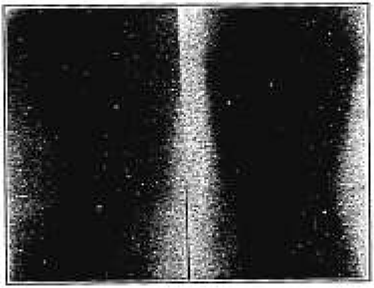


FIG. 33.—Case VIII. Two months later. The nail extension was applied fourteen days after fracture (9 cm. shortening). At present 1 cm. short—front and side view.

January 3, 1913. Firm union. Function of knee much better.

Epicrisis. Nail-extension was applied fourteen days after fracture and was maintained thirty-four days. The 9 cm. shortening on the sixteenth day was reduced to *nil.* There was delayed union. This accounted for the shortening which came after discontinuance of traction. A two-piece nail was used, and it was deemed unwise to use more than 23 pounds traction for fear of breakage.

CASE IX.—Charles H., aged fifty years (Dr. John A. Wyeth's service, Polyclinic Hospital).

November 22, 1912. Patient was standing on the end of a freight train, which was backing down. The train suddenly stopped, threw him off, and he became unconscious. He sustained a traumatic amputation of the big and second toes of his right foot, a fracture of the upper third of his right femur, and a concussion of the brain.

November 25. Third day after fracture, solid nail inserted under laughing-gas anesthesia; 12 pounds traction; one inch shortening.

November 28. No shortening. Traction wire broke.

December 1. 1 cm. shortening.

December 16. Twenty-first day, no shortening; apparent union; nail removed; removal required considerable force.

December 21. Wounds healed promptly.

December 30. *X*-ray (Fig. 34). Revealed a badly comminuted fracture of the neck and trochanter. The fragment indicated by the arrow was palpable and led to the diagnosis made above. Today there is three-fourths of an inch shortening. Abduction will be maintained by a cast.

FIG. 34.—Case IX. Comminuted fracture of greater trochanter and shaft (thirty-eighth day).

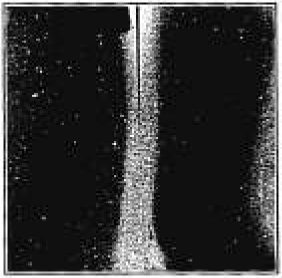


FIG. 35.—Case X. End-result six weeks after comminuted fracture of shaft. No shortening.

Epicrisis. The crushed condition of this man's foot would have made proper attention to it difficult had a Buck's extension been applied. As it was, dressings were not hindered by the nail-extension apparatus. This case emphasizes the value of controlling clinical observations by the *x*-rays.

CASE X.—Charles C., aged nine years (Dr. Ernest Fahnestock's service, J. Hood Wright Hospital, New York.)

November 23, 1912. Patient was hit by an automobile and sustained a fracture at the middle third of his left thigh.

December 2. Eight days after fracture there is a large effusion of the knee-joint. 2 cm. shortening. Under laughing-gas anesthesia; a solid nail inserted through the head of the tibia; 10 pounds traction, which was increased later to 15 pounds.

December 4. 1 cm. overcorrection; effusion less.

December 13. Effusion of the knee-joint gone.

December 24. Twenty-one days after insertion, nail removed easily; good union; large callus.

December 29. Nail holes clean. Can raise knee twelve inches from bed; active or passive flexion beyond this is painful.

December 30. Out of bed on crutches. (*X*-ray, Fig. 35.)

CASES IN WHICH NAIL-EXTENSION WAS APPLIED AND WHICH DIED FROM CAUSES HAVING NO RELATION TO THE METHOD EMPLOYED.

CASE XI.—Alice K., aged fifty-two years (Dr. Collins' service, City Hospital).

September 13, 1912. Patient broke her right hip.

September 20. Supracondylar insertion of Steinmann's two-piece nail by Dr. H. H. Janeway.

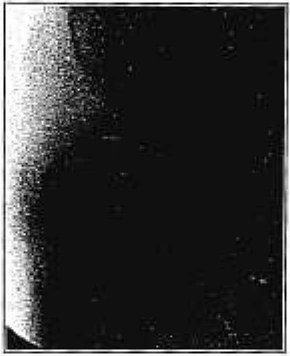


FIG. 36.—Case XI. Total absorption of femoral neck three days after fracture in a syphilitic subject. The head lies against the shaft.

September 21. Wassermann reaction was reported strongly positive. On account of her debilitated condition, she bore antispecific treatment poorly.

October 7. Seventeenth day after insertion, local pain around the nail; temperature, 102°.

October 10. Twentieth day, fever having continued, nail removed; 2 drams of pus escaped; nail was found broken at the screw-joint; but the ends of the tongs had kept the pieces of nail in position at approximately right angles to the bone.

October 11. Temperature normal; discharge less.

October 15. No union. *X*-rays show total absorption of the femoral neck, so that head rests against shaft (Fig. 36).

October 18. The patient has been gradually declining for the past two weeks. During the past week there has been no fever; she became much weaker this day; went into coma and died. Diagnosis: Death from syphilitic myocarditis. No autopsy.

Epicrisis. This was a fracture of the neck of the femur in a markedly syphilitic subject. Total absorption of the neck in thirty-two days. It is possible there was a previously existing gumma of the neck of the femur, predisposing to fracture at that point. The patient was intractably filthy in her habits. Inflammation of the nail hole, which occurred on the seventeenth day after insertion, promptly subsided after removal of nail and application of wet dressing. Patient died of her myocarditis a week after her temperature had reached normal. The nail broke at its joint under no undue strain. (Traction between 10 and 15 pounds.)

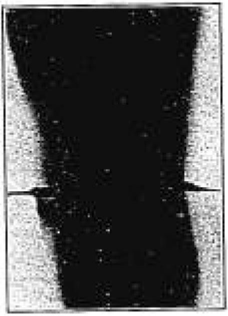


FIG. 37.—Case XII. A two-piece nail which broke at the joint. The pieces were held at approximately right angles by the tongs and continued to exert traction.

CASE XII.—Fritz D., aged forty-eight years (Dr. Collins' service, City Hospital).

October 27, 1912. A confirmed drunkard, fractured his thigh while intoxicated. Had delirium tremens four days after admission. Moderate icterus. Condition gradually improved.

November 1. Two-peice nail inserted; no anesthesia; 19 pounds traction.

November 2. Comfortable.

November 3. Again developed delirium; irrational. Developed a pneumonia, to which he promptly succumbed.

November 5. *X*-rays, taken while in delirium, show broken nail held in place by tongs (Fig. 37). No autopsy.